Research Memo 64-9E2-113-M3 December 3, 1964

Title: "Atomic Collision Processes Relating to the Ionosphere"*

Period of Report: September 1, 1964 - November 30, 1964

ARPA Order Number: 125-63 (Amd. 10)

Contract Number: NONR-2584(00)

Project Code Number: 3720

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Unless otherwise noted, the results given in this memo should be considered as preliminary.

This report covers progress made in the ARPA-ONR sponsored portion of our studies of atomic collision processes related to the upper atmosphere. The remainder of the program is reported under AF Contract 29(601)-6271, Project 7811.

1. Mass Spectrometer with Ion Velocity Filter

In the course of work on the production of O^- from CO it has been found that, apart from the main resonance capture peak in the cross-section occurring at about 10 eV, small subsidary peaks exist at higher energies, but below the threshold for pair production, presumably due to processes of the type $e + CO \rightarrow O^- + C^*$ (electronically excited). It is planned to search for similar reactions in other diatomic gases, particularly O_2.

Attempts to establish the appearance potentials of O^- from CO and CO_2 under various source conditions have provided values in substantial agreement with those obtained in previous work, which are too low for consistency with the accepted values of the electron affinity and dissociation energies involved. The apparatus has been modified recently to permit the study of gas mixtures. It will now be possible to detect and study any tendency for electro-negative gases to affect the source operation, by a well established appearance potential, say of $\dot{X}e$.

This work has been carried out by P. J. Chantry and G. J. Schulz.

2. High Pressure Mass Spectrometry

The mechanisms of formation of N_4^+ and N_3^+ ions in ion-molecule interactions in nitrogen have been further investigated. The results indicate that the N_4^+ ion is formed through processes involving N_2 ; N_2^+ $(A^2\pi_u)$ and N_2^+ $(B\,\Sigma_u^+)$. The N_3^+ ion formation appearance potential (21.1 ev) is consistent with the reaction $N_2^{+*} + N_2 \rightarrow N_3^+ + N$. It is further established the the N^+ ion does not enter into the formation of N_3^+ ions. There is some indication that at high pressures ($>200\,\mu$) the current changes from a quadratic to a linear dependence on pressure. This will be the case if the N_2^+ excited

state involved is a long lived one. The results lead to the conclusion that the $^4\Sigma_u^+$ state of N_2^+ is the excited state involved in the formation of N_3^+ ions.

N_2^+ formed from four body reactions has been observed. It is found that by appropriate choice of ion-source conditions, (high E/p), the N_2^+ ion resulting from four body collisions can be observed below the ionization potential of N_2^+. The early onset of N_2^+ under these conditions and the cubic dependence on pressure, lead us to the following processes for its formation:

$$N_2^* + N_2 \rightarrow N_4^+ + e$$

$$N_4^+ + N_2 \rightarrow N_2^+ + N_2.$$

This work has been carried out by R. K. Asundi and G. J. Schulz.

3. Transmission Experiments

The transmission experiment has been developed for a study of resonances in the elastic scattering of atoms under circumstances in which the resonance is small (say less than 3% of the elastic cross section). Such a transmission experiment, performed at rather high gas pressures (~ 0.3 torr) exhibits an enhancement of the resonance. The results of these experiments have been published in the Physical Review.

Recently, the enhancement technique has been applied to a study of atomic hydrogen. The experiment had to be modified to permit the use of a high flow rate of the gas in the collision region so that the atomic hydrogen (produced by a 200 watt microwave discharge) is preserved. The resonance in the elastic cross-section of atomic hydrogen has been found at an energy of 9.7 ± 0.15 eV. This result is in excellent agreement with the predictions of theory. Various compromises with good electron beam techniques prevented us from doing the experiment with as good an energy resolution as may be desirable. The results of this experiment have been published in Physical Review Letters.

This work has been done by G. J. Schulz.